

Raspberry Pi Computing Education Research Centre

Annual Report | 2023



In 2021, we established the Raspberry Pi Computing Education Research Centre, made possible with the generous support of the Raspberry Pi Foundation. This report contains the first update on the activities of the Centre. As a joint initiative between the University and the Raspberry Pi Foundation, the work of the Centre includes research activity that is carried out at the Foundation in collaboration with the University.

This year, Raspberry Pi Foundation's support has enabled us to enrol PhD students Laurie Gale and Salomey Afua Addo as well as supporting Dr Sue Sentance to work with the team to produce cutting edge research and to disseminate it through participation in conferences, seminars and workshops. The University of Cambridge would like to express their gratitude to the Raspberry Pi Foundation for the support of this budding research community.

In this report we describe the Centre team and their research activities, together with our outputs in the period. As this is our first report, we will include activity from 2021–2023, and thereafter this report will revert to be a genuinely annual report.



Introduction from the Director

The aim of the Raspberry Pi Computing Education Research Centre is to increase our understanding of the teaching and learning of computing, computer science, and associated subjects, with a particular focus on young people who are from backgrounds that are traditionally under-represented in the field of computing or who experience educational disadvantage.

The Centre was established in 2021, and I was delighted to be appointed as its first Director in October 2021. We held a formal launch at the Department of Computer Science and Technology in July 2022. We have now recruited two research students who have made an excellent start to their studies. We work collaboratively with researchers at the Raspberry Pi Foundation. This is a unique partnership, with the Centre team straddling both organisations and bringing together the academic strengths of the University with the reach and community of the Raspberry Pi Foundation.

Our three themes are broad and encompass both formal and non-formal education, framed around ensuring that all learners can access computer science education. Currently, our main research areas are AI education in school, culturally responsive computing teaching, physical computing, computing teacher experiences, gender balance, and programming pedagogy.

My role is to oversee the work of the Centre, supervising PhD students and leading on our funded projects. We are looking to build a broad coalition of supporters and partners who share our vision for increasing our understanding of the teaching and learning of computing in school. We are fortunate to have secured funding from several partners already. We've been delighted to have received a donation from Google to work on culturally responsive computing teaching in 2022, and a research grant from DeepMind to carry out the independent evaluation of a range of projects around AI education in school and non-formal learning in 2023, and support from the Micro:bit Educational Foundation towards a PhD student's fees.



We look forward to growing our community of partners over the coming year and to increase existing collaborations with other universities.

I hope you enjoy reading this short report on our activities and research outputs over the last two years.

A handwritten signature in dark ink, appearing to read 'Sue Sentance', written in a cursive style.

Sue Sentance
Director

Researchers and other contributors



Dr Saman Rizvi

ESRC Postdoctoral Fellow

Saman was awarded an ESRC postdoctoral fellowship to work within the Centre under the mentorship of Sue Sentance, to disseminate her PhD research on Learning Analytics and AI in Education. Currently, she is completing a study on inclusiveness in open, online computing education. She has also co-authored a journal paper reviewing literature on AI teaching and learning in K-12.



Laurie Gale

PhD student

Laurie began his PhD in October 2022 in the area of K-12 programming pedagogy. In particular, he is interested in improving the teaching and learning of debugging at a lower secondary level. Laurie is currently completing his first research study of the PhD, with the second to begin in September 2023. Aside from his PhD, Laurie has been involved with efforts from the Department of Computer Science and Technology's outreach planning.



Salomey Afua Addo

PhD student

Salomey began her PhD in January 2023 in the area of AI education for K-12. She is particularly interested in how children can improve their understanding of Artificial Neural Network(ANN) through physical computing. She is currently completing her first study on teachers' motivation to teach AI in K-12 settings in England. Aside from her PhD, Salomey has been involved in training students in scientific computing methods.



Dr Anjali Das
Research Associate
(April 2022–Jan 2023)

Anjali worked part-time on the Google-funded Culturally Responsive Computing Teaching research study we conducted in 2022, supporting the data collection and analysis of the project.



Yujeong (Alyson) Hwang
Research Assistant
(April 2022–April 2023)

Alyson has a social policy background and brought expertise and perspectives around sociological theory to the team. She worked part-time on the Google-funded Culturally Responsive Computing Teaching research study we conducted in 2022, supporting the data analysis and paper writing for this project. She is the lead author for a full paper we have published in August 2023 which looks at culturally responsive computing teaching through the lenses of the work of Bourdieu and Freire.



JungHa Woodward
Research Strategy Coordinator

Working as a member of the Research Strategy team in the University, JungHa's work spans event organisation, outreach and grant administration and provides much-needed support to help the Centre run smoothly. She is currently working as the main contact for the Centre enquiries and organising the WiPSCE conference.

Collaboration with the Raspberry Pi Foundation

We work closely on projects with the following research team members at the Raspberry Pi Foundation.



Dr Jane Waite

Senior Research Scientist

Jane's PhD is in the area of design in primary programming, and her research work at the Foundation is very versatile. She has overseen the design and implementation of a number of research studies including the work on culturally relevant pedagogy and on AI and machine learning, authoring papers in all these areas. Jane has also spearheaded new work on semantic wave theory applied to computing education, now being applied to Ada Computer Science, a collaborative project between the University and the Raspberry Pi Foundation that provides computing education materials for students and teachers.



Dr Bobby Whyte

Research Scientist

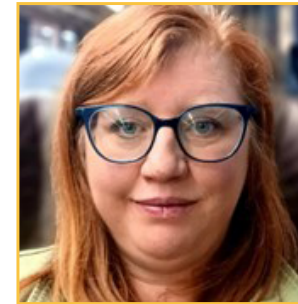
Bobby's PhD is in the area of primary computing education. Since joining the Foundation in July 2022, he has worked on the AI resource categorisation project and supported the culturally relevant computing project. He has also worked on the UKICTS survey project and the DeepMind external evaluation project at the Research Centre, producing multiple reports for DeepMind. He has co-authored a paper on the categorisation of AI resources, presented his research in the Raspberry Pi Foundation seminar series, and written articles for Hello World.



Dr Veronica Cucuiat

Research Scientist

Veronica's PhD is in the area of Learning Analytics. Since joining the Foundation in August 2022, she has worked on the AI resource categorisation project and supported the development of the ExperienceAI learning resources in collaboration with the wider Foundation team. Veronica is leading a research project, exploring the views of expert educators on the use of LLMs to explain IDE programming error messages. She has co-authored the paper on the categorisation of AI resources, written posts on different topics for the Raspberry Pi blog, and supported the wider Raspberry Pi AI-related activities.



Katharine Childs

Research Associate

Katharine worked on the primary computing culturally relevant resources project that was externally funded by Cognizant from 2022–2023. She has co-authored a paper on the initial workshops held with teachers that will be presented and published in September 2023. Katharine was also responsible for completing the recruitment and onboarding of schools to the Gender Balance in Computing randomised controlled trials and played a key role in disseminating the results, and managing the closedown and legacy assets of the programme.



Diana Kirby

Research Assistant

Diana supported the development of guidelines for culturally relevant learning resources, the first stage of our culturally relevant pedagogy for computing work, which was funded by ACM SIGSCE. She has worked on the UKICTS survey project from its initiation, co-authoring a paper comparing computing education policies and provision in the UK and Ireland with teachers' experiences. Since September 2022, Diana has worked on the independent evaluation of the DeepMind AI programme. She also helped to originate our research seminar programme and ran the seminars from May 2020 to January 2023.



Bonnie Sheppard

Programme Coordinator

Bonnie joined the team in April 2022 and has supported the AI resource categorisation project, UKICTS survey, primary computing culturally relevant resources project, and large language model pilot study. She developed our impact measurement protocol and gathers data on our output every month. Bonnie is also involved in our outreach efforts by contributing to the development of our Research Centre webpage and project webpages, organising large external events, such as the Research Centre launch in 2022 and the WiPSCE conference in 2023, and has been in charge of organising the online seminars since January 2023.



Dr Hayley Leonard

Research Scientist

(left July 2023)

Hayley Leonard worked on the primary computing culturally relevant pedagogy and resources project that was externally funded by Cognizant from 2022–2023. In the last year Hayley has led on the implementation of this project that aims to support primary teachers to adapt their own teaching resources using the principles of culturally relevant pedagogy. She has co-authored an article on the initial workshops held with teachers that will be presented and published in September 2023. Hayley made a huge contribution to the establishment and early stages of our work on culturally relevant pedagogy between 2021 and 2023.

Highlights

Formal Launch

On 20th July 2022, the Raspberry Pi Computing Education Research Centre celebrated its official launch at the Computer Science and Technology Department of the University of Cambridge. The event provided a formal platform for prominent researchers, educators, students, and industry professionals to convene and gain insight into the Centre's vision. Three speakers addressed various facets of computing education's historical significance, expressing unwavering enthusiasm for this pioneering venture in the realm of computing education research. The occasion not only marked a momentous initiation but also set forth a promising trajectory for the Centre as it endeavours to advance computing education practices through innovation and research.



Culturally responsive computing teaching

Culturally relevant pedagogy is a framework for teaching that emphasises the importance of incorporating and valuing all learners' knowledge, ways of learning, and heritage. Culturally responsive teaching is related and maintains that teachers need to understand students' cultural differences to be able to convert it into curriculum designs and create conducive teaching environments and support student's understanding of social justice issues.

The University was supported by Google to carry out a project investigating the implementation of culturally responsive computing in schools in England in 2022. Separately, the Raspberry Pi Foundation was funded by Cognizant to carry out a project from 2022-3 which focuses on primary teachers' confidence to adapt resources to make them more culturally relevant.

AI and Education

This year we have published a literature review on recent empirical studies relating to the teaching and learning of AI to young people. We've also reviewed hundreds of resources that introduce AI to children, and categorised them using a framework we've developed called SEAME.

We are delighted that the Research Centre has been selected by DeepMind, a leading AI company, to conduct an independent evaluation of their AI school education programme. DeepMind is partnering with six education charities and social enterprises in the UK to co-create a bespoke education programme to help tackle the gaps in STEM education and boost existing programmes through funding, volunteering, and the development of new AI resources. The evaluation runs through 2023 and 2024.

Semantic wave theory

We've been collaborating with Queen Mary University of London and the University of Sydney in the use of semantic waves in computer science knowledge building. We have completed a small research project investigating how feedback to students who have answered multiple-choice questions can be improved using semantic wave theory. In this pilot we worked with teachers and students who use the Ada Computer Science platform. There is a significant opportunity to conduct further research in this area; semantic waves is gaining interest in computer science education as a way to review and develop learning activities in our field.

WiPSCE conference

In September 2023, the Centre will host the 18th WiPSCE Conference on Primary and Secondary Computing Education Research. Sue Sentance is both Program Chair and Local Chair for this ACM-affiliated conference for which we expect 100 attendees.





Further information

Publications 2022–23

Publications from 2021-2023 are included in this report as this is the first report of this nature.

Sentance, S., Barendsen, E., Howard, N. R., & Schulte, C. (Eds.). (2023). *Computer science education: Perspectives on teaching and learning in school*. Bloomsbury Publishing. Second Edition. (edited book)

Rizvi, S., Sentance, S., Childs, K., Leonard, H., Quinlan, O., & Waite, J. (2022, October). 'Use of storytelling to increase engagement and motivation in computing in lower primary schools'. In *Proceedings of the 17th Workshop in Primary and Secondary Computing Education* (pp. 1-2). <https://doi.org/10.1145/3556787.3556876>

Rizvi, S., Waite, J., & Sentance, S. (2023). 'Artificial Intelligence teaching and learning in K-12 from 2019 to 2022: A systematic literature review'. *Computers and Education: Artificial Intelligence*, 100145. <https://doi.org/10.1016/j.caeai.2023.100145>

Hwang, Y, Das, A., Waite, J., & Sentance, S. (2023). 'Using a sociological lens to investigate computing teachers' culturally responsive classroom practices'. In: *Proceedings of the 2023 ACM Conference on International Computing Education Research*.

Gale, L. & Sentance, S. (2023). 'Investigating the Attitudes and Emotions of K-12 Students Towards Debugging'. In *Proceedings of the 2023 Conference on United Kingdom & Ireland Computing Education Research*.

Leonard, H., Childs, K., Waite, J. & Sentance, S. (2023). 'Engaging primary (K-5) computing teachers in culturally relevant pedagogy through Professional Development'. In *Proceedings of the 2023 Conference on United Kingdom & Ireland Computing Education Research*.

Waite, J., Das, A., Hwang, A., & Sentance, S. (2023). 'Supporting educators to adapt K-12 computing lessons using culturally relevant pedagogy using Areas of Opportunity'. In *Proceedings of Frontiers in Education 2023* (to be published in October).

Waite, J., Tshukudu, E., Cucuiat, V., Whyte, R., & Sentance, S. (2023). 'Towards a framework for learning content analysis in K-12 AI/ML education'. In *Proceedings of Frontiers in Education 2023* (to be published in October).

Publications 2021–22

Sentance, S., Kirby, D., Quille, K., Cole, E., Crick, T., & Looker, N. (2022, September). 'Computing in School in the UK & Ireland: A Comparative Study'. In *Proceedings of the 2022 Conference on United Kingdom & Ireland Computing Education Research* (pp. 1-7). <https://doi.org/10.1145/3555009.3555015>

Tshukudu, E., Sentance, S., Adelakun-Adeyemo, O., Nyaringita, B., Quille, K., Zhong, Z. (2022). 'Investigating K-12 computing education in four African countries (Botswana, Kenya, Nigeria and Uganda)'. In *ACM Transactions on Computing Education*. <https://doi.org/10.1145/3554924>

Gardner, T., Leonard, H. C., Waite, J., & Sentance, S. (2022). 'What do we know about computing education for K-12 in non-formal settings? A systematic literature review of recent research'. In *Proceedings of the 2022 ACM Conference on International Computing Education Research*, 264–281. <https://doi.org/10.1145/3501385.3543960>

Tshukudu, E., Waite, J., Rizvi, S., & Sentance, S. (2022, July). 'Teachers' Motivations to Learn about ML and AI'. In *Proceedings of the 27th ACM Conference on Innovation and Technology in Computer Science Education* Vol. 2 (p. 609). <https://doi.org/10.1145/3502717.3532148>

Leonard, H.C., Quinlan, O. and Sentance, S., 2021. 'Female pupils' attitudes to computing in early adolescence ACM International Conference Proceeding Series', Doi: 10.1145/3481282.3481289

Waite, J., Franceschini, A., Sentance, S., Patterson, M & Sharkey, J. 2021. 'An online platform for teaching upper secondary school computer science'. United Kingdom and Ireland Computing Education Research conference. Association for Computing Machinery, New York, NY, USA, Article 3, 1–7. DOI: <https://doi.org/10.1145/3481282.3481287>

Morrison, B., Quinn, B., Bradley, S., Buffardi, K., Harrington, B., Hu, H., Kallia, M., McNeill, F., Ola, O., Parker, M., Rosato, J., & Waite, J. 2022. 'Evidence for Teaching Practices that Broaden Participation for Women in Computing'. In *Proceedings of the 2021 Working Group Reports on Innovation and Technology in Computer Science Education (ITiCSE-WGR '21)*. Association for Computing Machinery, New York, NY, USA, 57–131. DOI: <https://doi.org/10.1145/3502870.3506568>



Other publications and reports

Raspberry Pi Computing Education Research Centre (2023). *UK and Ireland Computing Teacher Survey: survey results (technical report)*. Available at: <https://computingeducationresearch.org/wp-content/uploads/2023/04/UK-Ireland-Computing-Teachers-Survey-survey-results.pdf>

Raspberry Pi Computing Education Research Centre (2023). *Bringing culturally responsive teaching to K-12 computing education*. Project Report. Available at: https://computingeducationresearch.org/crp_report_2023-2/

Sentance, S. & Waite, J. (2022). 'Perspectives on AI and data science education'. In *AI, data science, and young people. Understanding computing education (Vol 3). Proceedings of the Raspberry Pi Foundation Research Seminars*. rpf.io/seminar-proceedings-vol-3-sentance-waite

Leonard, H. C. and Kunkeler, T. (2021). 'Why the 'digital divide' does not stop at access'. In *Understanding Computing Education (Vol 2): Equity, Diversity and Inclusion. Proceedings of the Raspberry Pi Foundation Research Seminars*. Available at: rpf.io/seminar-proceedings-vol-2-leonard-kunkeler

Leonard, H. C., Kirby, D., Sentance, S., Chinaka, L., Deutsch, M., Dimitriadis, Y. and Goode, J. (2021). 'Localising culturally responsive computing teaching to an English context: developing teacher guidelines'. In *Understanding Computing Education (Vol 2): Equity, Diversity and Inclusion. Proceedings of the Raspberry Pi Foundation Research Seminars*. Available at: rpf.io/seminar-proceedings-vol-2-leonard-et-al

Waite, J. & Sentance S., 2021 *Teaching programming in schools: A review of approaches and strategies. Raspberry Pi Foundation Research Report*. November 2021. [ISSN 2514-586X \(19\)](https://doi.org/10.2514/586X)

Waite, J. 2022 'Design in Primary Programming Activities'. In Sentance, S., Barendsen, E., Howard, N. R., & Schulte, C. (Eds.). (2023). *Computer science education: Perspectives on teaching and learning in school*. Bloomsbury Publishing. Second Edition.



Talks and speaking engagements

Sue Sentence. 'Gender Balance in Computing'. Up North Online conference. February 2023.

Sue Sentence. 'Gender Balance in Computing'. I Love Computing Conference. February 2023.

Jane Waite. Keynote talk. 'Culturally Relevant Pedagogy Research'. I Love Computing Conference. London, February 2023.

Katharine Childs. 'Engaging girls in coding clubs and beyond'. Raspberry Pi Foundation. Clubs Conference 2023. Cambridge, March 2023.

Jane Waite. 'How can computing education research help me run my club?' Raspberry Pi Foundation. Clubs Conference 2023. Cambridge, March 2023.

Sue Sentence. Invited talk. 'Global Computer Science Education'. CSEd Botswana Summit. March 2023.

Sue Sentence. 'Astronomy or telescopes? Seeking a research agenda for computing education for young people'. CRESTEM Annual Lecture. King's College London. April 2023.

Sue Sentence. 'What does Tech Mean for the Future of Education?' Cambridge Tech Week Fringe at Hughes Hall. May 2023.

Jane Waite. 'Culturally Relevant Pedagogy - what does it mean for our classroom practice?' LGfL Let's Celebrate II Conference. June 2023.

Jane Waite. 'Computing At School - Transforming Tech Education. Invited panel member'. British Computer Society, London. June 2023.

Jane Waite. 'Semantic Waves: Great feedback and structured explanations'. Computer Science Teachers Association (CSTA) Conference. July 2023.

Sue Sentence. Keynote. 'Teaching computing in school: is K12 research reaching classroom practice?' Koli Calling, November 2021

Sue Sentence. Keynote. 'Gender Balance in Computing: the need for a multi-faceted approach'. ISSEP 2022 conference. September 2022.

Sue Sentence. Invited Talk. 'Teaching programming: research-informed strategies and their use in the classroom'. STEM Trailblazers event, Swinburne University of Technology, Sarawak, Malaysia, July 2023.



Community contributions

Sue Sentance is a member of the Oversight Committee, Digital Education Futures Initiative (DEFI), Hughes Hall, Cambridge.

Sue Sentance is an Advisory Board member, CSEdBotswana.org, an initiative to grow computer science education in Botswana.

Sue Sentance is a member of the Data Skills Task Force at the Alan Turing Institute.

Sue Sentance is an Advisory Board member for Gen AI, a Finnish research project on AI Education.

Sue Sentance is an external evaluator for the CS Linc programme in Ireland.

Jane Waite is a member of the Computing At School (CAS) Board and Chair of the CAS Research and Universities working group.

Jane Waite and Sue Sentance are members of the BCS School Curriculum and Assessment Committee.

Sue Sentance is an Advisory Board member of the SCARI-COMP project.

Data sets

Sentance, S., Tshukudu, E. and Quille, K., 2022. *METRECC Africa 2020 data*
Doi: [10.17863/CAM.87121](https://doi.org/10.17863/CAM.87121)

Sentance, S., Kirby, D., Quille, K., Cole, E., Crick, T. and Looker, N., UK and Ireland
Computing Teacher Survey Dataset 1

